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Nearshore Navigation And Communication Based On Deliberate EM Signals

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LONG-TERM GOAL

We seek to understand and utilize deliberately produced EM signals in the coastal ocean. Our studies are undertaken to provide a means for communicating with and guiding an autonomous underwater vehicle (AUV) and other autonomous sensor systems, such as moored instruments. We want to include multiple effects in our models, such as environmental noise (e.g., surface waves, breaking waves, magnetotelluric signals), seabed electrical conductivity, variable bottom depth and coastline, and deliberate EM signals. The ultimate goal is to understand these factors well enough to allow for reliably estimating signal-to-noise ratios in planning coastal EM operations.

OBJECTIVES

The immediate objectives are to study the fundamental EM propagation modes in realistic shallow coastal environments having non-uniform three-dimensional geometrys and to examine various sources of environmental noise expected for such regions. The environmental EM noise includes fields generated by external sources in the ionosphere and magnetosphere, by the dynamo action of the ocean flow through the earth's main magnetic field, and by artificial sources such as from the 50/60 Hz utility power grids. As a proximate objective, a numerical model is being developed as a tool for investigating these elements.

APPROACH

The bulk of this work is being conducted by R. Tyler and involves primarily the development, validation, and implementation of a three-dimensional, finite-difference time-domain numerical model capable of simulating EM field propagation in realistic three-dimensional situations. A substantial effort is also being directed by R. Tyler and T. Sanford in literature review and theoretical considerations aimed at illuminating the environmental EM noise topics.

WORK COMPLETED

The work by Tyler began 1 July, 1999. Prior to this, Sanford visited collegues at the Coastal Systems Station (CSS) in Panama City to learn about their requirements. In these few months we have obtained and installed necessary computing equipment and software, designed and tested initial elements of the numerical model, and conducted a literature review on natural EM noise in the marine environment for frequencies in the range of "DC" to 1 kHz. Tyler has also attended two international conferences; MARELEC 99 (a conference on marine electrodynamics) held in Brest in early July, and 3DEM-2 (a

conference on numerically modeling three-dimensional EM fields) held in Salt Lake City in late October.

RESULTS

Of course, at this incipient stage of the project we do not have primary results. One interesting point that has come to light which may count as a "result" at least because it affects our project development is the following: a review of non-classified literature reveals that observations of coastal EM fields in the frequency range of interest are essentially non-existent. The scant understanding of this topic which is mostly inferential remains today as assessed by the ONR-sponsored workshop a decade ago (Chave et al. 1990). In addition, our initial theoretical consideration of expected environmental noise implicate myriad possible effects within which the scant observations offer little guidance.

IMPACT/APPLICATIONS

There is a need for non-acoustical means of navigating and controlling AUVs, communicating with autonomous instruments, and detecting submerged and buried objects in shallow water. In principle, the extremely low-frequency EM signals we are investigating can be used for these purposes. In practice, however, not enough is known to predict reliable signal-to-noise ratios for particular applications. Although the EM propagation paths in the coastal environment are themselves non-trivial and will be illuminated in our study, we will probably have a greater impact in our studies of the environmental noise because this is as of yet the most poorly understood ingredient in operational signal-to-noise ratio estimates.

TRANSITIONS

None as of yet but we intend to make our results and model code available to CSS collegues and perhaps others.

REFERENCES

Chave et al., 1990, Report of a Workshop on the Geoelectric and Geomagnetic Environment of Continental Margins, Scripps Institute of Oceanography Reference 90-20, Prepared for the Office of Naval Research under Contract N00014-9-J-3064.